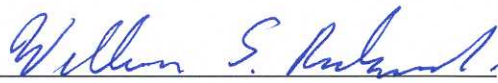


## CRITERION 424

### COOLING TOWERS

#### SIGNATURES

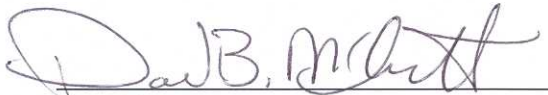


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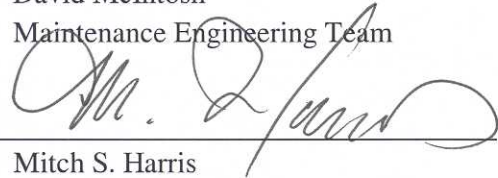


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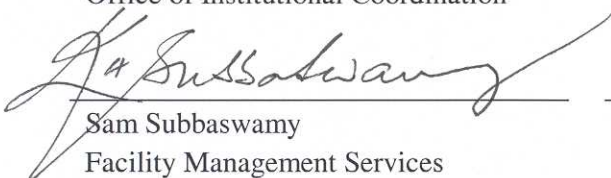


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**RECORD OF REVISIONS**

<b>Revision No.</b>	<b>Date</b>	<b>Description</b>
0	07/25/01	Initial issue. Inclusion of additional information, examples, and required statements from the approved Writers Guide, Criterion 101. Reviewed and included lessons learned from 1993 to present.

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## **CRITERION 424**

### **COOLING TOWERS**

#### **1.0 PURPOSE**

This document establishes the minimum requirements and best practices for the operation and maintenance of cooling towers at LANL facilities. This document addresses the requirements of LIR 230-05-01 (Ref.10.14), "Operations and Maintenance Manual."

The implementation of these requirements and recommendations satisfies DOE Order 430.1A (Ref. 10.1), "Life Cycle Asset Management," Attachment 2 "Contractor Requirements Document," Paragraph 2, Sections A through C, which in part require UC to "...maintain physical assets in a condition suitable for their intended purpose," and employ "preventive, predictive, and corrective maintenance to ensure physical asset availability for planned use and/or proper disposition." Compliance with DOE Order 430.1A is required by Appendix G of the UC Contract.

#### **2.0 SCOPE**

The LANL complex has over 50 mechanical-draft cooling towers servicing institutional and programmatic equipment. This Criterion addresses operations, inspections, and maintenance of all water evaporative cooling towers at LANL. Other evaporative cooling units such as air washers, water evaporative chillers, refrigerant evaporative condensers, and air evaporative coolers will be covered under a separate Criterion. Water treatment for cooling towers is addressed in Criterion 402 (Ref. 10.4), "Water Treatment of Open Cooling Units."

This Criterion does not address corrective maintenance actions required to repair or replace equipment.

#### **3.0 ACRONYMS AND DEFINITIONS**

##### **3.1 Acronyms**

<b>CFR</b>	Code of Federal Regulations
<b>DOE</b>	Department of Energy
<b>LIG</b>	Laboratory Implementing Guidance
<b>LIR</b>	Laboratory Implementing Requirement
<b>LPR</b>	Laboratory Performance Requirement

<b>LPS</b>	Lightning Protection System
<b>O&amp;M</b>	Operations and Maintenance
<b>PPE</b>	Personal Protective Equipment
<b>PP&amp;PE</b>	Personal Property and Programmatic Equipment
<b>RP&amp;IE</b>	Real Property and Installed Equipment
<b>SSC</b>	Structures, Systems, and Components
<b>UC</b>	University of California

### **3.2 Definitions**

Attached, as Appendix A is a glossary of cooling tower terms. The use of the glossary will aid in understanding cooling tower operations.

## **4.0 RESPONSIBILITIES**

### **4.1 FWO-Systems, Engineering and Maintenance (SEM)**

**4.1.1** FWO-SEM is responsible for the technical content of this Criterion and assessing the proper implementation across the Laboratory.

**4.1.2** FWO-SEM shall provide technical assistance to support implementation of this Criterion.

### **4.2 Facility Manager**

**4.2.1** Responsible for operations and maintenance of institutional, or Real Property and Installed Equipment (RP&IE) under their jurisdiction, in accordance with the requirements of this document.

**4.2.2** Responsible for operations and maintenance of those Personal Property and Programmatic Equipment (PP&PE) systems and equipment addressed by this document that may be assigned to the FM in accordance with the FMU-specific Facility/Tenant Agreement.

### **4.3 Group Leader**

**4.3.1** Responsible for implementing operational and maintenance surveillance programs including the preparation and maintenance of required procedures and documentation for PP&PE under their jurisdiction that is covered by this Criterion.

## **5.0 PRECAUTIONS AND LIMITATIONS**

### **5.1 Precautions**

This section is not intended to identify all applicable precautions necessary for implementation of this Criterion. A compilation of all applicable precautions shall be contained in the implementing procedure(s) or work control authorization documents. The following precautions are intended only to assist the author of a procedure or work control document in the identification of hazards/precautions that may not be immediately obvious.

- 5.1.1** Cooling tower fans are temperature controlled and can start at any time.
- 5.1.2** Coordinate all repairs that require any outage or fan lockout with all users since one tower may serve many buildings.
- 5.1.3** Cooling tower environments are wet and slippery. Use care when climbing access ladders and walking on decks. Use extreme care in winter when ice increases the slipping hazards.
- 5.1.4** Older towers may have asbestos cement siding and air intake louvers. Some may have asbestos paper drift eliminators. See Occurrence Report ALO-LAO-LANL ADO-ADMIN-1996-006, which addresses these issues.

### **5.2 Limitations**

The intent of this Criterion is to identify the minimum generic requirements and recommendations for SSC operation and maintenance across the Laboratory. Each user is responsible for the identification and implementation of additional facility specific requirements and recommendations based on their authorization basis and unique equipment and conditions, (e.g., equipment history, manufacturer warranties, operating environment, vendor O&M requirements and guidance, etc.). Nuclear facilities and moderate to high hazard non-nuclear facilities will typically have additional facility-specific requirements beyond those presented in this Criterion. Nuclear facilities shall implement the requirements of DOE Order 4330.4B (Ref. 10.15) (or 10 CFR 830.340, Maintenance Management, when issued) as the minimum programmatic requirements for a maintenance program. Additional requirements and recommendations for SSC operation and maintenance may be necessary to fully comply with the current DOE Order or CFR identified above.

## **6.0 REQUIREMENTS**

Minimum requirements that Criterion users shall follow are specified in this section. Requested variances to these requirements shall be prepared and submitted to FWO-SEM in accordance with LIR 301-00-02 (Ref. 10.16), "Variances and Exceptions to Laboratory Operations Requirements," for review and approval. The Criterion users are responsible for analysis of operational performance and SSC replacement or refurbishment based on this analysis. Laws, codes, contractual requirements, engineering judgement, safety matters, and operations and maintenance experience drive the requirements contained in this section.

### **6.1 Operations Requirements**

- 6.1.1** Cooling tower related operations and water treatment must comply with NPDES Permit No. N170028335. Related requirements are contained in Criterion 402 (Water Treatment of Open Cooling Units).

*Basis:* NPDES Permit No. N170028335 requires proper operation and maintenance in Section 13. (Ref. 10.8)

### **6.2 Maintenance Requirements**

- 6.2.1** Cleaning operations on cooling towers with EPA-permitted outfalls must notify ESH-18 at least 48 hours prior to draining basins.

*Basis:* This is a requirement of Criterion 402, Water Treatment of Open Cooling Units. (Ref. 10.4)

- 6.2.2** Cleaning operations on cooling towers that discharge to sanitary requires 24-hour notice to SWSC Plant Supervisor.

*Basis:* This is a requirement of Criterion 402, ES&H, and O&M Manual for O3A Category Outfalls. (References 10.4, 10.6)

- 6.2.3** Cooling tower solids are disposed of in accordance with LANL LIR 404-00-03 if toxic or hazardous compounds are present. Cooling tower solids free of toxic or hazardous material may be disposed of in a MUNICIPAL SOLID WASTE FACILITY (Land Fill). Beneficial use of cooling tower solids such as snow and ice treatment is acceptable and encouraged, provided the solids are free of toxic or hazardous material.

*Basis:* This is a requirement of LIR 404-00-03 (Ref. 10.7), Hazardous and Mixed Waste Requirements for Generators. NMED letter from Charles A. Hules to Richard Perkins, dated June 8, 1995 (Appendix B).

## **7.0 RECOMMENDATIONS AND GOOD PRACTICES**

The information provided in this section is recommended based on acceptable industry practices and should be implemented by each user based on his/her unique application and operating history of the subject systems/equipment.

### **7.1 Operations Recommendations**

- 7.1.1** Operate cooling towers in accordance with operation instructions furnished by the manufacturer.

*Basis:* Cooling Towers are specific to the heat loads they are servicing per the Facility Engineering Manual and manufacturer's specifications.

- 7.1.2** Keeping a log of cooling tower measurements tracks performance and aids in determining heat transfer problems. Measurements should include:

- Hot water temperature
- Cold water temperature
- Wet bulb temperature
- Water Flow
- Range
- Approach

*Basis:* "Cooling Tower Manual," Chapter 5, published by the Cooling Tower Institute is an excellent source of field test measurements. (Ref. 10.11)

### **7.2 Maintenance Recommendations**

#### **7.2.1 Weekly**

##### **7.2.1.1 Cooling Towers**

Perform the following inspections and functional checks:

- Check for water leaks and broken water lines.
- Inspect for excessive algae growth on decks or fill.
- Inspect for plugged nozzles.
- Verify operation of blow down.
- Verify chemical feed pump operation.
- Activate mercury floats or mechanical floats to check make-up water operation.
- Check water level in basin.
- Check water distribution on distribution deck.



- Inspect for open doors.
- Listen for unusual noise or vibration from fans or pumps.
- Inspect for oil leaking from gear drive.
- During freezing conditions, check for heavy ice build up on air louvers and fill.
- Feel fan and pump motors for over heating.
- Check sump screens for clogging.

*Basis:* Criterion 402 (ref. 10.4), LANL maintenance experience and Marley Operation and Service Manual. (Ref. 10.12)

## **7.2.2 Semi-Annually**

### **7.2.2.1 Gear Reducer Box:**

- Check oil level and fill if necessary

*Basis:* LANL maintenance experience and Marley Operation and Service Manual. (Ref. 10.12)

### **7.2.2.2 Fan Drive Shaft**

- Lubricate universal joints if required.

*Basis:* LANL maintenance experience and Marley Operation and Service Manual. (Ref. 10.12)

### **7.2.2.3 Cooling Tower Pumps**

*Basis:* See Criterion 412 and 510. (Reference 10.4, 10.5)

### **7.2.2.4 Cooling Tower Fans**

- Inspect blades for build-up
- Observe fan for unbalance or vibration. Unbalanced fan blades can fail catastrophically.

*Basis:* See ORPS Report SR-WSRC-CSWE-1995-0011. (Ref. 10.\_\_)

## **7.2.3 Annually**

### **7.2.3.1 Gear Reducer**

- Change oil, using manufacturer's recommended type.
- Inspect oil lines and fittings for leaks.
- Inspect keys and keyways.
- Clean/replace sight glasses.
- Check vents.

- Tighten all mounting bolts to torque specifications.
- Move drive shaft laterally to check for excessive play in pinion shaft. Excessive play indicates worn bearings.

*Basis:* LANL maintenance experience and “Cooling Tower Technology,” Second Edition. (Ref. 10.13)

#### **7.2.3.2 Motors**

*Basis:* See Criterion 510. (Ref. 10.5)

#### **7.2.3.3 Mechanical Coupling**

- Check for alignment and damage.
- Check belts (if applicable) for damage, tension, and alignment.
- Lubricate pillow block bearings per Manufacturers specifications.

*Basis:* LANL maintenance experience and “Cooling Tower Technology,” Second Edition. (Ref. 10.13)

#### **7.2.3.4 Fan Assembly**

- With protractor, check fan blades for correct pitch (per manufacturer’s specifications).
- Check fan tip to wall clearance (1 ¾ to 2 inches is recommended range).
- Torque hub bolts.
- Inspect blades for cracks or damage
- Check direction of fan rotation.
- Check/test vibration cut out switches.
- Clean fan blades.

*Basis:* CTI – “Cooling Tower Manual,” Chapter 13. (Ref. 10.13)

#### **7.2.3.5 Thermal Transfer**

- Inspect fill for integrity, uniformity and unusual wear.
- Inspect drift eliminators for damage.
- Inspect nozzles for plugging and proper water distribution.
- Inspect air intake louvers for damage.

*Basis:* CTI – “Cooling Tower Manual,” Chapter 13. (Ref. 10.13)

**7.2.3.6 Structural Members**

- Inspect wood structural beams for rot and deterioration.
- Check connectors for tightness and corrosion.
- Inspect condition of handrails, ladders, and decking.

*Basis:* CTI – “Cooling Tower Manual,” Chapter 13. (Ref. 10.13)

**8.0 GUIDANCE****8.1 Operations Guidance**

It is important to know the design conditions and operational parameters of cooling towers to operate at highest efficiencies. The operations and service manuals supplied by manufacturers are a valuable source of this information.

**8.2 Maintenance Guidance**

- 8.2.1** JCNNM Maintenance Manual # MM44-40-004 (Ref. 10.10), “Cooling Unit Maintenance and Water Treatment Manual,” provides acceptable guidance for a cooling tower maintenance program, provided it has been reviewed and approved by FWO-SEM.

## 9.0 REQUIRED DOCUMENTATION

Maintenance history shall be maintained for cooling towers to include, as a minimum, the parameters listed in the Table 9-1 below:

**Table 9-1 Documentation Parameters**

<b>MAINTENANCE HISTORY DOCUMENTATION PARAMETERS</b>				
<b>PARAMETER</b>	<b>ML 1</b>	<b>ML 2</b>	<b>ML 3</b>	<b>ML 4</b>
<b>Manufacturer's Name Plate Data</b>	<b>X</b>	<b>X</b>		
<b>Maintenance Activities</b>				
Repair / Adjustments	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
PM Activities	<b>X</b>	<b>X</b>		
<b>Equipment Problems</b>				
Failure Dates	<b>X</b>	<b>X</b>		
Failure Root Cause	<b>X</b>	<b>X</b>		
<b>Inspection Results</b>				
Inspection Date	<b>X</b>	<b>X</b>		
SSC Condition	<b>X</b>	<b>X</b>		

*Basis:* Documentation of the parameters listed in Table 9-1 above satisfies the requirements of LPR 230-07-00, Criteria 2, (Ref. 10.17) which states; "Maintenance activities, equipment problems, and inspection and test results are documented."

## 10.0 REFERENCES

- 10.1** DOE Order 0430.1A, Life Cycle Asset Management, October 1984.
- 10.2** LIR 230-04-01.0, Laboratory Maintenance Management Program, 24 April 1998.
- 10.3** LIR 230-09-00.0, Inventory and Categorization of Facilities, 19 February 1997.
- 10.4** Criterion 402, Rev. 0, Pump Systems.
- 10.5** Criterion 510, Rev. 0, Electric Motors.
- 10.6** ESH-18 Operations and Maintenance Manual for EPA Category 03A Outfalls, September 1998.
- 10.7** LIR 404-00-03, Hazardous and Mixed Waste Requirements for Generators.
- 10.8** NPDES Permit No. NM0028355.
- 10.9** LIR 404-00-04, Managing Solid Waste, 12 August 1994.

- 10.10** JCNNM Maintenance Manual, MM 44-40-004, Cooling Unit Maintenance and Water Treatment Manual.
- 10.11** Cooling Tower Manual, Cooling Tower Institute.
- 10.12** Marley Cooling Tower Fundamentals.
- 10.13** Cooling Tower Technology, Second Edition.
- 10.14** LIR 230-05-01.0, "Operations and Maintenance Manual."
- 10.15** DOE O 4330.4B, "Maintenance Management."
- 10.16** LIR 301-00-02.0, "Variances and Exceptions to Laboratory Operations Requirements."
- 10.17** LPR 230-07-00.0, "Maintenance History," Performance Criteria 2.

## **11.0 APPENDICES**

**Appendix A:** Glossary of Cooling Tower Terms, Cooling Tower Technology, Second Edition.

**Appendix B:** NMED letter dated 8 June 1995.

## **APPENDIX A**

### **GLOSSARY OF COOLING TOWER TERMS**

**GLOSSARY OF COOLING TOWER TERMS****ACCEPTANCE TESTING**

Uniform standards to determine the water cooling capability of cooling towers. Instrumentation and measurements are performed in accordance with methods outlined in the Cooling Tower Institute (CTI) Bulletin Acceptance Test Procedure (ATP) 105 or ASME PTC 1958. Tests should be utilized to ascertain that new or rebuilt cooling towers produce Design Conditions that the Owner is paying for. Testing normally is done by third party—not the Owner or Contractor. Confidential report is submitted to person paying for testing and the Owner.

**ACCESS TUNNEL**

Opening in Natural Draft Tower used for access to the cold water basin. It can be large enough for a man only, or large enough for mechanical equipment.

**AIR FLOW**

Total amount of dry air and associated water vapor flowing through the tower, measured at exhaust from the tower and converted to standard air which has a density of 0.075 lb. per cu. ft. Units: quantity, lb. per hr; velocity, fpm. Standard air (acfm) (density at DBT, WBT and pressure/ 0.075).

**AIR HORSEPOWER**

The measure of useful power required to move a given air rate against a given resistance. The ratio of air horsepower to fan input horsepower is the measure of fan efficiency.

**AIR INLET**

Area of cooling tower where air is initially introduced into unit by action of airflow generator.

**ALGAE**

A low form of plant life, which generally requires sunlight and air for existence. Causes plugging of heat exchanger tubes and cooling tower distribution systems.

**ALGAECIDE**

A toxic material, which will retard or prevent the growth of algae and shines. Some of the more commonly used algaecides are chlorine, copper sulfate and phenolic compounds.

**AMBIENT TEMPERATURE**

External outdoor temperature as reported by periodic readings, also known as the dry bulb temperature, measured in the regular manner with conventional instruments.

**AMBIENT WET BULB TEMPERATURE**

Wet bulb temperature of air measured windward of the tower and free from the influence of the tower. Unit: 0F. 0C.

**ANCHOR BOLT**

A threaded bolt imbedded in a concrete basin or fitted to supporting members, to which an anchor casting is attached.

**ANCHOR CASTING (Column Anchor)**

A device for attaching the tower structure to the foundation; it does not include the anchor bolt.

**APPROACH**

Temperature difference in degrees between the water leaving the tower and the wet bulb temperature of the air entering the cooling tower. Performance is measured in terms of APPROACH. The cost of a 60F-approach tower for the same heat load would be approximately 50% higher than a unit cooling to a 100F approach.

**ATMOSPHERIC TOWER**

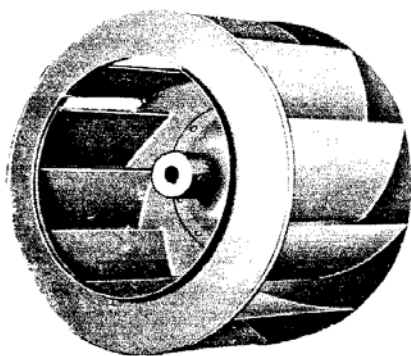
One in which air movement is dependent upon atmospheric conditions, not on mechanical fans, to force or induce air through the tower. The hot moist air rises in the chimney pulling in colder outside air through the intake louvers.

**AUTOMATIC VARIABLE PITCH (AVP)**

Sensors and pneumatic controllers change fan blade angles to utilize minimum HP depending upon the varying heat rejection load required at any given time. High Energy Saver.

**AXIAL FLOW**

Air movement parallel to spinning axis generated by rotating fan blades.



**CENTRIFUGAL FAN causes air movement at right angles to rotating impeller axis.**

**BALANCING VALVE**

Hand or mechanically operated valve installed in each riser pipe of a multicell tower to permit altering the water flow to the unit to equalize or change the volume over each cell.

**BASIN**

Bottom collecting area of cold water returning to suction line. Crossflow tower has additional top hot water distribution basin and in some few cases, an intermediate hot water distribution basin is located halfway between the top basin and the bottom collecting basin.

**BASIN CURB**

Top level of the retaining wall of the cold water basin; usually the datum point from which tower elevation points, tower static and total pumping heads are measured.

**BAY**

The area between two bents or lines of framing members.

**BENT**

A line of structural framework composed of columns, girts or ties; a bent may incorporate diagonal bracing members.

**BEVEL WASHER**

A metal fitting used to accommodate through-bolts to angular position of a diagonal member, usually connecting to columns or other framework members.



**BLOWDOWN (Purge)**

Remove impurities concentrated in circulating water due to intensification of solids by water evaporation loss, by bleeding off a small percentage of the total flow.

**BOARD FOOT**

A unit of measurement of lumber represented by a board 1' long, 12" wide, and 1" thick or its cubic equivalent.

**BROWN ROT**

In wood, decay in which the attack concentrates on the cellulose and associated carbohydrates rather than on the lignin, producing a light to dark brown friable residue.

**CANOPY (Natural Draft Tower)**

Connects the hyperbolic shell to the cooling section, acting as an air conduit and air seal between the two.

**CAPACITY**

Average amount of circulating water volume in the cooling system at any given time expressed in terms of gallons per minute (GPM) flow.

**CASING**

Enclosure for sidewall and endwall of a counter-flow tower and endwall of a crossflow tower exclusive of the louvers.

**CELL**

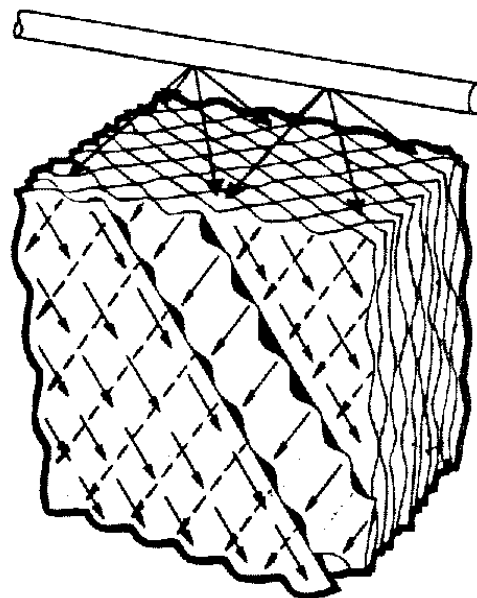
One complete unit of a cooling tower consisting of one distribution system, normally one set of mechanical equipment and partition walls. Each cell can be designed to operate independently of its neighbors and receive an equal share of the total water volume if required for the flexibility of the system.

**CELL DIMENSIONS**

(a) Width: dimension perpendicular to tower longitudinal axis and usually at right angles to the louver area; (b) Length: dimension parallel to longitudinal axis and the plane where louvers are usually placed; (c) Height: distance from basin curb to top of fan deck but not including fan stack. Nominal width and length are measured from and to the column centerlines. (see Nominal Tower Dimensions).

**CELLULAR FILL**

Most efficient fill packing developed. Spreads water droplets into thin sections throughout the cells of the fill thereby cooling a larger surface area for the same energy. A good design will have a lower static pressure—for the same amount of work performed—than wood splash bar packing or steel configuration.



**CELLULAR FILL most efficient heat transfer surfaces developed for cooling tower use.**

**CENTRIFUGAL FAN**

Forced draft or blower wheel (also called “squirrel cage”) causing air movement at right angles to rotating impeller axis.

**CHARACTERISTIC**

*KaYIL* (Crossflow) or *KaV/L* (Counterflow) is a measurement of the order of difficulty for the cooling tower heat rejection requirements exclusive of the fill. The characteristic is located on the vertical or “Y” scale, the ordinate. The value is expressed as a dimensionless number and is usually obtained by locating the Liquid to Gas ratio and intersection of the approach curve. Integration of the Tchebrycheff Formula will also locate the value on the vertical trigonometric scale.

**CIRCULATING WATER FLOW**

The amount of hot water flowing into the tower. Units: quantity, lb. per hr. (one U.S. gallon 8.33 lbs.); volume, GPM; velocity, FPS.

**COIL SHED**

Portion of the tower structure housing atmospheric (tubular) heat exchangers.

**COLD WATER TEMPERATURE (CWT)**

Temperature of the water entering the cold water basin before addition of make-up or removal of blowdown.

**COLUMN**

Framework member; a main vertical supporting member in the tower framework.

**CONVECTION**

Transference of heat by the circulation of the heated parts of gas or liquid whereby heated portions are lighter and rise vertically.

**COOLING FACTOR**

L/G (L over G)—Ratio of the pounds of water being circulated per unit time to the pounds of dry air per unit time, which are cooling the water.

**COOLING POND**

Large reservoir on inexpensive real estate whereby warm water is cooled as air contacts pond’s relatively large surface area and colder water is either reused or discharged into public waterway.

**COOLING TOWER**

A device for the evaporative cooling of water by contact with air. This is achieved partially by an exchange of latent heat resulting from the evaporation of some of the circulating water, and partially by transfer of sensible heat to the air.

**COUNTERFLOW**

Tower where air movement and hot water mix at 180° counter to each other with the air moving vertically through the fill packing and water.

**CROSSFLOW**

Tower where air movement and hot water mix at 90° or cross to each other with the air moving horizontally through the fill packing and water.

**CROSS OVER PIPING (See Header)****CROSS STRUTS (Natural Draft Tower)**

Framework that holds up the hyperbolic shell, the number of which will vary depending on shell size.

**CYCLES OF CONCENTRATION**

Compares dissolved solids in make-up with solids in the circulating water. Since chlorides are soluble, for example, cycle of concentration is equal to ratio of chlorides in circulating water to chlorides in make-up.

**DECIBEL**

Unit of sound level measurement, gauged by converting the pressure energy of noise to electrical impulses and transferring them to a voltmeter calibrated in decibels.

**DECK STRINGER**

Holds the splash bars of the fill deck in a fixed position with respect to air and water flow.

**DELIGNIFICATION (Soft Rot)**

Loosening of surface fibers of softer lignites causing weakening of timbers or splash bars, reducing members in cross-section and strength.

**DESIGN CONDITIONS**

Thermal parameters for which the cooling tower is purchased and/or rebuilt. Expressed as cooling a given GPM flow of water entering the tower at a specified temperature, cooling through a given range leaving the tower at the required temperature and having a designated approach to a stated wet bulb. A certified test (see Acceptance Testing) should be incorporated in the job specifications.

**DE-SILTING SUMP (Natural Draft Tower)**

Area in the cold water basin, usually a low point, where any silt can be flushed to a drain.

**DEW POINT**

The temperature at which a given mixture of air and water will have a relative humidity of 100% saturation.

**DIAGONAL (Brace)**

Framework member; any load-bearing member transmitting forces at other than a right angle with reference to columns or horizontal ties.

**DIFFUSION DECK**

A fill deck, which is located directly under the distribution basin or nozzle bank. The purpose of this deck is to receive water from the basin or nozzle and distribute it uniformly over the fill decks.

**DISCHARGE STACK**

A walled enclosure extending upward above the eliminators to direct exhaust air vertically away from fans in a forced draft tower.

**DISTRIBUTION BOX**

Used in conjunction with the manifold and valve assembly in a Crossflow Tower to disperse the hot water uniformly in all directions thereby increasing the effectiveness of the distribution nozzles.

**DISTRIBUTION SYSTEM**

Mechanical method of uniformly passing the hot water over the fill area preparatory to cooling. Low pressure spray through piping and nozzles is normally used in counterflow tower, and gravity drop is mainly utilized in crossflow towers.

**DOUBLE-FLOW WATER COOLING TOWER**

A Crossflow Tower with two fill sections and one plenum chamber which is common to both.

**DOWNSPOUT**

A short vertically placed pipe or nozzle used in a gravity distribution system to divert water from a flume or lateral to a splasher.

**DRIFT**

Water droplets, which are entrained in the airstream as it passes through the tower and are thrown out of the hot air discharge plenum or fan stack. Manufacturers limitations are 2/10ths of 1 % allowable, but vary with specifications.

**DRIFT ELIMINATORS**

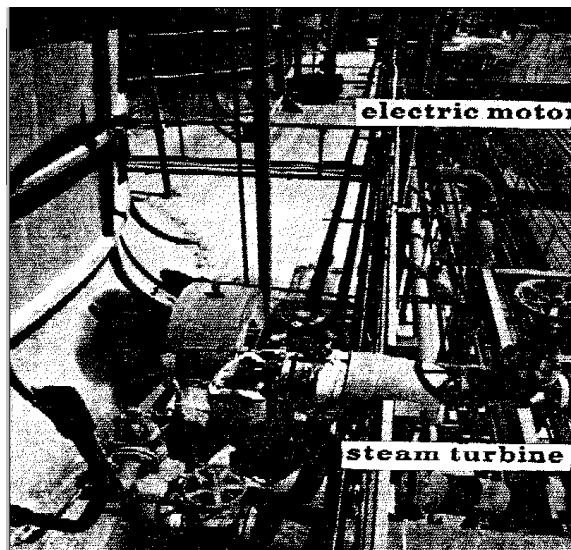
Baffling that causes discharging hot air with entrained water droplets to change direction a number of times, thereby causing the droplets to hit the eliminator surface and fall back into the tower at every change of direction.

**DRIVE SHAFT**

A device including a coupling (or couplings) for transmitting torque from the driver to the speed reducer.

**DRIVER**

Primary drive for the fan drive assembly; usually an electric motor.



**DRIVER** primary mover for the fan drive assembly; usually an electric motor, but may be steam turbine or other power source.

**DRY BULB**

Ambient temperature of air measured in the regular manner with conventional instruments.

**DRY ROT**

A term loosely applied to any dry, crumbly rot but especially to that which, when in an advanced stage, permits the wood to be crushed easily to a dry powder.

**ELIMINATOR BOARD**

The smallest component in a wood drift eliminator assembly, which is usually installed in a fixed position at an angle to the direction of air flow. Also known as Eliminator Baffle (Blade).

**END WALL**

The wall on the end of the tower structure.

**ENTHALPY**

The total heat content, which is the sum of the sensible heat of the air and water vapor plus the latent heat of vaporization of the water.

**EVAPORATION LOSS**

Water evaporated from the circulating water into the atmosphere by the cooling process.

**EVAPORATIVE COOLING**

Heat transfer where a liquid condenses into its gaseous state thereby giving up latent heat. The simplest example of this basic premise of cooling tower operation: wet the back of your hand then blow on the wetted surface. The drop in temperature on your skin is due to evaporative condensation.

**EXHAUST AIR**

The mixture of air and its associated vapor leaving the tower.

**EXHAUST WET-BULB TEMPERATURE**

Average wet bulb temperature of the air discharged from the tower.

**EXIT BASIN TEMPERATURE**

Temperature of the circulating water leaving the cold water basin. If blowdown is removed from or make-up added to the basin, the temperature will be affected accordingly.

**EXIT DIAMETER (Natural Draft Tower)**

Diameter of the shell at the top.

**FAN**

An airfoil rotating to move air through a cooling tower normally parallel to the axis of the fan shaft.

**FAN DECK**

Surface enclosing the top of an induced draft tower. In a counterflow tower, the fan deck covers the entire top surface of the tower. In a crossflow tower, the fan deck covers only the tower plenum area, leaving the distribution system exposed. An extended fan deck encloses the distribution system and covers the entire top surface of the tower, except of course, the cut for fan diameter.

**FAN DRIVE ASSEMBLY**

Mechanical components furnishing power to the fan, usually consisting of driver, drive shaft, speed reducer, and supporting members.

**FAN DRIVER INPUT**

Horsepower input to the driver. For 3-phase alternating current (ac) motors.  
 $\text{hp (amps) (volts) (3) (Power Factor)}$

**FAN DRIVER OUTPUT**

Brake horsepower output of the driver to the drive shaft.  $(\text{Fan driver input}) \times (\text{motor efficiency})$ .  $(\text{Efficiency}) + 746$

**FAN GUARD**

A protective screen installed either at the inlet of a forced draft fan or at the exit of an induced draft fan.

**FAN PITCH**

The angle, which a fan blade makes with the plane of rotation; degrees from horizontal.

**FAN STACK**

Cylindrical or modified cylindrical structure enclosing the fan discharge in induced draft towers. Usually constructed of fiberglass materials, wood and metal are also utilized.

**FILL BARS**

The assembly of splash bars comprising the tower filling. Fill bars intercept the downward fall of water at regular intervals, forming splash surfaces, which cause water drops to break into smaller droplets, and provide wetted surfaces for air-water contact.

**FILL DECK**

The assembly of splash bars comprising the tower filling. See FILL BARS for description of operation in a Crossflow Tower.

**FILL HANGER**

Support system in a Crossflow Tower for fill bars which hold fill in place.

**FILL PACKING**

Baffling placed within the casing of the tower to provide large water surface areas for heat transference. Two classes of materials are used. Splashbars of wood, metal, transite, plastic, or film pack (cellular fill) made of thin section. The splash type cools water droplets bouncing down in the vertical or horizontal air stream, while film packing turns the droplets into thin films for highly efficient cooling by producing a larger surface area for the air movement to cool.

**FLEXIBLE COUPLING**

Resilient connecting assembly that transmits the power in the fan driver to the gear unit through the drive shaft.

**FLOW CONTROL VALVE**

A manually controlled valve generally located in the hot water supply line.

**FLUME**

A trough, which may be totally enclosed or open at the top. Flumes are sometimes used in cooling towers to distribute the hot water over the fill.

**FOG**

Saturated air being discharged from the cooling tower under atmospheric conditions whereby the ambient atmospheric temperature cannot absorb all of the moisture as vapor, and excess fog condenses. The intensity of the fog plume is a function of the heat rise of air passing through the tower and the temperature and humidity of the ambient air. Fog plumes are normally permissible since there are no droplets of water raining out of the discharge area. However, on large industrial sites this could cause icing of the roads in the winter and restricted visibility, which could necessitate corrective action.

**FORCED DRAFT**

Design whereby the air intake is at the bottom forcing the air up and through the tower, normally by a centrifugal blower.



**FOUNDATIONS (Natural Draft Tower)**

Support material beneath the tower cross struts and cooling section. Foundations can be caissons, spread footing (tension ring) or piles.

**FRAMEWORK MEMBERS**

The structural members designed to support all live and dead loads imposed. They consist of columns, horizontal ties, diagonals, and joists and beams.

**GEARBOX**

Power transmission unit on cooling tower, which provides a right angle turn from motor shaft and couplings to gear down motor speed thereby generating power of air movement from the fan. Transmission unit, which reduces RPM from the power source through a system of gears to the design speed for the fan to produce optimum airflow.

**GIRT (See Horizontal Tie)****HANDRAIL**

A horizontal or sloping rail placed along an access way or at the edge of a platform. Usually at 3'—6" above the walkway or floor.

**HEADER**

In a counterflow tower, the main pipe carrying hot water to a series of laterals for distribution over the fill material. In a crossflow tower, the main pipe carrying hot water to each cell hot water distribution basin longitudinally. Crossover pipe carries the hot water laterally within the cell.

**HEART WOOD**

The wood extending from the pith to the sapwood, the cells of which no longer participate in the life processes of the tree. Heartwood may contain phenolic compounds, gums, resins, and other materials that usually make it darker and more decay resistant than sap wood.

**HEAT EXCHANGE**

A device for transferring heat from one substance to another. Heat transfer can be by direct contact, as in a cooling tower, or indirect, as in a shell and tube condensor.

**HEAT LOAD**

The amount of heat dissipated in a cooling tower measured in BTU's; is equal to the weight of water circulated per unit time multiplied by the cooling range. BTU per hr. = (GPM) (500) (HWT-CWT).

**HORIZONTAL TIE**

Framework member; a load-bearing horizontal connecting member in the tower framework.

**HOT WATER TEMPERATURE**

Temperature of circulating water entering the distribution system. Unit: 0F.

**HUMIDITY, ABSOLUTE**

Amount of water vapor contained in the air at a given condition usually expressed in pounds of water per pounds of dry air.

**HUMIDITY, RELATIVE**

Ratio of water vapor pressure in the air to the saturated vapor pressure at the same temperature usually expressed as a percentage.

**MECHANICAL DRAFT**

Design whereby airflow is constantly being generated by fans or rotor, either induced by the fans on top or forced draft by impellers located at bottom of air inlet.

**MECHANICAL EQUIPMENT**

Refers to air moving devices only. Induced draft normally consists of fan blades mounted on a hub attached to vertical shaft of gear reducer box with a flexible coupling fixed to the horizontal (or input shaft of gear box) and transmission shaft with another flexible coupling joining shaft to motor shaft. Forced draft towers normally are belt driven from motor pulling to fan sheave, which is keyed to Rotor Fan (or squirrel cage) shaft. Some fan designs are direct coupled to motor.

**MECHANICAL EQUIPMENT SUPPORT**

Members, which comprise the primary support for the fan, drive assembly.

**MERKEL'S THEORY**

The total heat theory, which has been almost universally adopted to calculations of tower performance. All heat transfer taking place at any position in the cooling tower is proportional to the difference between the total heat of the air at that point in the tower and a total of air saturated at the temperature of the water at that point in the tower.

**MOTOR RATED HORSEPOWER**

Horsepower rating inscribed on nameplate of the motor driving the fan.

**NATURAL DRAFT WATER COOLING TOWER**

One in which air movement is dependent upon the difference in density between the entering air and internal air. As the heat of the water is transferred to the air passing through the tower, the warmed air tends to rise and draw in fresh air at the base of the tower.

**NET EFFECTIVE VOLUME**

That portion of the total structural volume within which space the circulating water is in intimate contact with the airflow through the tower.  
Unit: cu.ft.

**NOMINAL TOWER DIMENSIONS**

Width and length measured from and to column centerlines; height measured from top of basin curb to top of fan deck (counterflow design) or to top of distribution basin (crossflow design).

**OBSTRUCTION LIGHTS (Natural Draft Tower)**

Warning lights required by FAA regulations, placed on the outside of the hyperbolic shell.

**OVERALL TOWER DIMENSIONS**

(a) *width*: overall dimensions perpendicular to the tower's longitudinal axis; (b) *length*: overall dimension parallel to the air inlet louvers and the longitudinal axis; (c) total *height*: distance from basin curb to top of fan stack.  
Dimensions measured in feet.

**PACKING—(See Filling)****PARTITION**

An interior wall subdividing the tower into cells or into separate fan plenum areas.

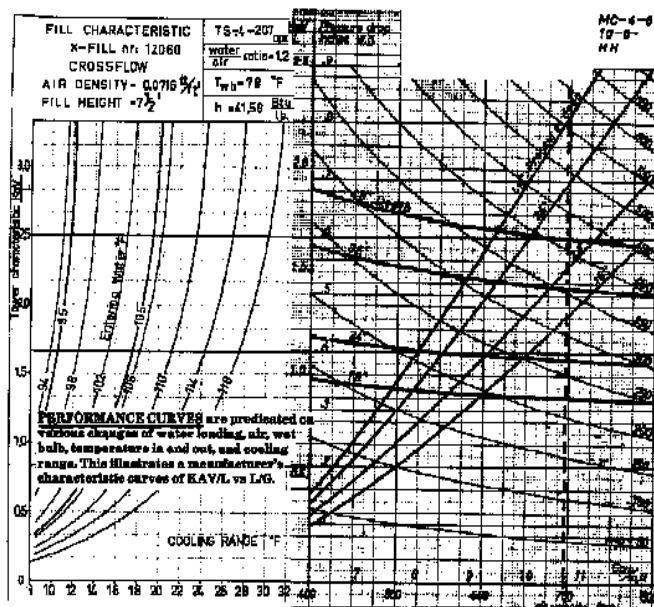
**PEDESTALS (Natural Draft Tower)**

Used as a transition from the cross struts to the foundation.



### PERFORMANCE CHARACTERISTIC, KAV/L

Relative efficiency factor for a given L/G ratio, volume, and cross section of a cooling tower, related to the design heat transfer capability of the fill, expressed by the formula  $KAV/L$  where "K" equals the coefficient of mass transfer in pounds per hour per square foot which is a unit of humidity potential. "A" equals total interfaced area per unit packed volume of tower in foot squared per foot cubed. "V" equals packed tower volume foot cubed per foot squared. "L" equals mass velocity of liquid in pounds per hour per foot squared of tower cross section. Liquid/Gas ratio relationship of water to air volume and water volume. This is a valuable tool used to rate the performance of a tower for heat transfer characteristics of a specific type of fill referred to as L/G or L over G.



### PERFORMANCE CURVES

Performance of a cooling tower is rated in terms of water temperatures, approach, wet bulb temperature, range, static pressure, and air movement. The ratio of a cooling tower is established by developing a series of charts that relate to these variables.

### pH OF WATER

The measure of purity, acidity, or alkalinity of water. 7.0 is arbitrarily selected as the neutral area where both the hydrogen and hydroxyl ions are present in exactly the same proportions so that the water is neutral. Lower than 7.0 is acid, higher is alkaline on a scale of 0 to 14.

### PIER

In a wood tower an interior column support used to elevate column footings above the basic floor or foundation grade. Also known as Internal Pier.

### PILASTER

An exterior column support, usually an integral part of the basin wall. Also known as External Pier.

### PITCH ANGLE

Fan blade angle measured between the horizontal and upper side of the fan blade from leading edge to trailing edge. (discharge side)

**PITCHING FAN BLADES**

Angle of attack on fan blades of most modern cooling towers is adjustable. A bubble is initially set at the manufacturers recommended pitch angle at a designated place on each blade, the blade is turned to the angle and locked in place. This is done for all blades and the fan is rotated while the amperage is checked. Additional air volume or less air volume may be generated by the fans depending upon the pitch of the blade. It is important to know that the amperage of the system should remain approximately 10% below the motor plate.

**PITOT TUBE**

An instrument that operates on the principle of differential pressures. The primary use on cooling towers is the measurement of circulating water rate.

**PLAN AREA**

The cross section of the working area of the tower, measured in feet of length and width.

**PLENUM**

The enclosed space between the drift eliminators and the fan stack in induced draft towers, or the enclosed space between the fan and the filling in forced draft towers.

**PLUME**

Visible exhaust from a cooling tower.

**POND**

In a cooling pond heat is dissipated from the surface of a body of water by evaporation, radiation and convection. A spray pond was the original heat transfer cooling device. An improvement was the addition of an aeration spray extending the water surface by bringing it in contact with the air. The weaknesses of the cooling ponds are their dependence on the unpredictable prevailing winds, and excessive area of real estate required.

**POWER FACTOR**

The ratio of true power (watts) to the apparent power, as indicated by the product of amps X volts.

**PRESSURE DROP**

Static pressure or amount of resistance of air movement through the tower caused by obstructions such as air louver inlets, fill configuration, tower supports, spray system piping, drift eliminators, static and mechanical equipment components, fan cylinder resistance and construction.

**PSYCHROMETER**

An instrument used primarily to measure the wet bulb temperatures. Either a sling or a mechanically aspirated type of psychrometer is acceptable provided the instrument is properly shielded from radiation and the air across the wick is limited to approximately 1,000 ft./min.

**PUMPING HEAD**

Energy required to raise the water to the distribution elevation and overcome friction losses through pipe, valves, fittings and nozzles. It is expressed in feet of liquid the pump must move and equals the totals of friction loss, static head, plus pressure drop through the distribution system.

**PURGE**

Removing the concentrated impurities from evaporation or discharging water from the system to prevent precipitation of solids. (Blowdown).

**RADIATION**

Heat loss caused by a body warmer than surrounding air giving off its latent heat by flowing thermally “downhill” from the hot body to the cooler area.

**RANGE**

The numerical difference between the water temperature entering the cooling tower at the distribution system and the cold water temperature leaving the sump of the cooling tower.

**RECIRCULATION**

A phenomenon where the hot exhaust air is forced downward and back into the cooling tower mixing with and lowering the cool fresh inlet air, usually due to design or placement problems. This raises the wet bulb temperature of the entering air above that of the ambient air and greatly reduces tower performances.

**REDISTRIBUTION BASIN**

An elevated basin installed between the hot and cold water basins in a crossflow tower to maintain uniform water distribution throughout the entire height of the fill.

**RISER**

Piping which connects the circulating water supply line from the level at the base of the tower or the supply header to the tower inlet connection.

**SAFETY**

A cooling tower is dangerous. Fan blades can and have killed. A power lockout is mandatory at the fan location. If unavailable—a watch should be established at the power source if it cannot be padlocked out. Initial fan start-up must be visually cleared prior to energizing; Fan, rail, ladder, and louver guards are to be maintained. A Buddy system should be utilized for interior repairs. Primary mandate is simple—use common sense.

**SAFETY HANDRAIL**

Railing around top of tower, platforms and stairways; usually composed of a top handrail, knee- rail and toeboard (depending on location).

**SAP WOOD**

The wood of pale color near the outside of the log. Under most conditions the sapwood is more susceptible to decay than heartwood.

**SENSIBLE HEAT**

The “heat you can feel” the heat required to change the temperature of the air or water. Hot water gives up a portion of its heat to the colder air by the heat “flowing downhill” from hot to cold.

**SHELL DIAMETER (Natural Draft Tower)**

Diameter of the shell at the top of the curb, measured from inside of cross struts to outside of cross struts.

**SHELL HEIGHT (Natural Draft Tower)**

Dimension from top of curb to top of the hyperbolic shell.

**SINGLE FLOW WATER COOLING**

A Crossflow Tower having a fill section on one side of the plenum chamber only.

**SOFFIT (Natural Draft Tower)**

The underside of the ring beam, forming the bottom part of the hyperbolic shell. Generally it is thick at the base and is the first portion of the shell above the cross struts.

**SOFT ROT**

Decay developing under very wet conditions in the outer wood layers, caused by cellulose destroying microfungi that attack the secondary cell walls and not the inter cellular layer.

**SPEED REDUCER**

A device to change speed of the driver to the speed desired for the fan.

**SPLASH BAR**

Horizontal component of a fill deck in a tower, which constitutes the principal splash surface.

**SPLASHER**

Used in a gravity distribution system to receive water from a downspout and effect uniform spreading of the water over the wetted area of the tower.

**SPRAY FILLED WATER COOLING TOWER**

A tower, which has no, fill. Water to air contact depends entirely on the break-up of the water by means of pressure spray nozzles.

**SPRAY NOZZLE**

Device used in a distribution system to break up the flow of the circulating water into droplets and effect uniform spreading of the water over the wetted area of the tower.

**STATIC PRESSURE DROP**

Reduction of air movement through the tower due to the resistance of internal components such as air intake louvers, fill packing, water distribution system, internal supporting beams, drift eliminators, fan stack configuration.

**STANDARD AIR**

Has a density of 0.075 lb. per cu. ft., which is air at 680F DBT, 50 percent RH and 29.92 in. HG (and substantially equivalent to 70<sup>0</sup> F dry air).

**SUCTION SCREEN**

Screen over water sump or pump suction pit on tower cold water basin, prevents debris from entering pump and piping system.

**SUMP**

Depressed section of the cold water collecting basin where the cooled water is returned to the heat source, be it the condensers, compressors, or process water equipment.

**SUPPLY HEADER**

Portion of the water supply system from which riser or inlet connection receives the circulating water flow.

**THERMAL CAPACITY**

The number of gallons per minute (GPM) a cooling tower will handle for a specified range, wet bulb temperature, and approach. Also simply known as CAPACITY.

**THROAT DIAMETER (Natural Draft Tower)**

Diameter of the shell at its narrowest point.

**TOWER DIMENSIONS**

(a) Width: overall dimension perpendicular to the tower longitudinal axis; (b) Length: overall dimension parallel to the air inlet louvers and the longitudinal axis; (c) Total height: distance from top of basin curb to top of fan stack.

**TRANSVERSE**

Always measured perpendicular to air intakes.

**UNDERFLOW WATER COOLING TOWER**

A crossflow tower with a forced draft fan located in a horizontal plane at the bottom of the plenum chamber. Air from the plenum travels horizontally through fill sections and discharges vertically at each end of the tower.

**VELOCITY REGAIN STACK**

A venturi shaped fan cylinder. The increased in performance obtained on this type of cylinder is due to the reduction in total head above the fan. The attendant decrease in total head differential across the fan results in an increase in air rate at constant horsepower or a decrease in horsepower at constant air rate.

**VIBRATION CUT-OUT SWITCH****WATER COOLING TOWER**

An enclosed, steady flow device for cooling water by evaporation and sensible heat exchange through direct contact with air.

**WATER LOAD**

Circulation rate of water over the tower, irrespective of temperature range.

**WATER LOADING**

Circulating water flow expressed in gallons per minute (GPM) per square foot of effective horizontal wetted area of the tower. Unit: GPM/ft.2.

**WET BULB**

The temperature of saturated air. At 100% humidity the wet bulb temperature equals the dry bulb reading. The lower the humidity, the drier the air and the greater the difference in reading. The lower the wet bulb, the more work a cooling tower can do. A cooling tower cannot cool the water below the wet bulb temperature of the inlet air.

**WET BULB TEMPERATURE (WBT)**

Temperature indicated by a psychrometer. Also known as the thermodynamic wet bulb temperature or the temperature of adiabatic saturation. Unit: 0F.

**WET/DRY TOWER**

A wet (evaporative) cooling tower in combination with a dry (non-evaporative) heat exchanger system, used to reduce or abate cooling tower fog during cold weather by modifying the tower exhaust air condition.

**WIND LOAD**

The load applied to a structure by a wind blowing against its surface. Wind load is expressed in pounds per square foot. Unit: lbs./ft.2.

**WINTERIZATION**

Modification of one or more cells to operate under freezing ambient temperatures. Consists of installing steam or electrical heating coils in basin, additional water distribution system below the fill packing to by-pass going through the decks, together with necessary valving, and fan reversal switch, if required, to keep heat in tower if water cannot by-pass fill to help melt ice formation. Safety switch used to de-energize the driver circuit should the mechanical equipment assembly vibrate excessively.

## **APPENDIX B**

**NMED LETTER DATED JUNE 8, 1995**



State of New Mexico  
**ENVIRONMENT DEPARTMENT**  
Harold Runnels Building  
1190 St. Francis Drive, P.O. Box 26110  
Santa Fe, New Mexico 87502  
(505) 827-0169

GARY E. JOHNSON  
GOVERNOR

June 8, 1995

MARK E. WEIDLER  
SECRETARY

EDGAR T. THORNTON III  
DEPUTY SECRETARY

Richard Perkins, Ph.D  
Johnson Controls  
1900 Diamond Drive  
Los Alamos, New Mexico 87544

Dear Dr. Perkins:

This letter is in response to our meeting of June 7, 1995 concerning the waste material generated in the Lab's water cooling processes. As I understand, the material is generated through evaporation and is a composite of silica, clay and trace elements found in the community's potable water supply. Analysis, including TCLP, has been done and the material is neither toxic nor hazardous. The material is a solid and free of liquids.

The material, by definition, is solid waste and is either a "sludge", or "other discarded material" resulting from industrial or commercial operations. The Regulations list sludge as a special waste, but special wastes are defined as solid wastes "that have unique handling, transportation, or disposal requirements to assure protection of the environment and the public health, welfare and safety". Based on the information provided in our discussions, this material does not meet that criteria and may be disposed of in a municipal solid waste facility. Please document periodic testing and analytical results for compliance purposes.

You also mentioned, the material may have beneficial uses, such as snow and ice treatment during winter. We encourage such diversion of solid waste material from the waste stream for beneficial use. If you have any other questions, please feel free to contact me at (505) 827-2924.

Sincerely,

Charles A. Hules, Manager  
Compliance Monitoring & Enforcement

CAH:dg

cc: Gerald Silva, Chief, SWB  
Michael Brown, Johnson Controls